PCT/GB 2004 / 0 0 4 0 3 0

PATENTS • DESIGNS • The Patent Office • COPYRIGHT • TRADE MARKS

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

REC'D 21 OCT 2004
WIPO PCT

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 8 October 2004

Patents Form 1/77

Patents Act 1977
(Rule 16)

The Patent Office

THE PATENT OFFICE
G
02 SEP 2004
LONDON

1/77

03SEP04 E923219-1 D03052
P01/7700 0.00-0419495.7 NONE

The Patent Office
Cardiff Road
Newport
Gwent NP10 8QQ

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1. Your reference

   A30541

2. Patent application number *(The Patent Office will fill in this part)*

   0419495.7 — 2 SEP 2004

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   BRITISH TELECOMMUNICATIONS public limited company
   81 NEWGATE STREET
   LONDON, EC1A 7AJ, England
   Registered in England: 1800000

   Patents ADP number *(if you know it)*

   1867002

   If the applicant is a corporate body, give the country/state of its incorporation

   UNITED KINGDOM

4. Title of the invention

   BROADBAND TELECOMMUNICATIONS

5. Name of your agent *(if you have one)*

   "Address for Service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   BT GROUP LEGAL
   INTELLECTUAL PROPERTY DEPARTMENT
   PP: C5A, BT CENTRE
   81 NEWGATE STREET
   LONDON, EC1A 7AJ, ENGLAND

   Patents ADP number *(if you know it)*

   ~~1867001~~ 8772378001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day/month/year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.

   (See note (d))

   YES

Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	-
Description	- 06
Claim(s)	- 02
Abstract	- 00
Drawing(s)	- 04 +4

10. If you are also filing any of the following, state how may against each item

Priority Documents

Translations of priority documents

Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*

Request for preliminary examination and search *(Patents Form 9/77)*

Request for substantive examination *(Patents Form 10/77)*

Any other documents *(please specify)*

11. I/We request the grant of a patent on the basis of this application.

Signature(s) Date:

02 September 2004

V.CHABASSEUR. ~~LLOYD, Barry George William~~, Authorised Signatory

12. Name and daytime telephone number of person to contact in the United Kingdom **Mark WATSON** **020 7356 6163**

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

Broadband Telecommunications

In recent years, particularly with increasing use of the internet, there has been an upsurge of interest in providing higher data rates to users. One objective of development in this area, in countries with a heavy historical investment on copper access networks, has been to make use of existing twisted-pair telephone lines. One result of this has been the Asymmetrical Digital Subscriber Line (ADSL) approach in which it was found that an existing copper pair from a telephone exchange to a telephone subscriber's premises could, using suitable modulation techniques, support significant downstream data rates, of the order of 1.5Mbit/s. However the actual rate obtained in practice depends on the quality and length of the path from the exchange and an alternative proposal, providing higher data rates is to make use of the copper pair only from some point rather closer to the user. This is sometimes referred to as very high speed Digital Subscriber Line (VDSL), and these technologies tend to be referred to generically as "xDSL".

Figure 1 illustrates such an "fibre to the cabinet" arrangement. A telephone exchange 1 provides telephony service via cables 2 (perhaps containing 1000 twisted copper pairs) to street cabinets (or cross-connect points) 3, from which rather smaller twisted-pair cables 4 feed distribution points 5. Individual twisted pairs 6 feed from the distribution point to subscriber's premises 7 to feed telephone equipment 8. Broadband service is provided from the exchange 1 by a multiplexer/demultiplexer 9 which multiplexes signals, using ATM or SDH techniques, onto one or more optical fibres 10, feeding the cabinet 3, and similarly demultiplexes signals travelling in the opposite direction. Within the cabinet 3 is (for each fibre) an optical receiver 11 and transmitter 12, demultiplexer 13, multiplexer 14 and xDSL modems 15 which are then connected via filters 16 to the copper pairs of the cable 4 leading to the distribution point 5 and thence via the pairs 6 to the subscriber premises 7 where a filter 17 separates (in the case of downstream signals) and combines (for upstream traffic) conventional telephony signals on the one hand and xDSL signals for data equipment 18 on the other. A power supply 19 is also provided in the cabinet to supply power to the receivers 11, transmitters 12, demultiplexers 13, multiplexers 14 and modems15.

According to the present invention there is provided a telecommunications network comprising:

a telephone exchange (or a communications station);

electrical transmission lines connecting the exchange (or the communications station) to user terminations;

data transmission means;

optical carriers connecting the data transmission means to at least one interface, located between the exchange (or the communications station) and user terminations, for converting optical signals from an optical carrier into electrical signals for transmission over one of the electrical transmission lines;

wherein, for each of a plurality of user terminations requiring data service:

(a) a dedicated one of said optical carriers is provided;

(b) the data transmission means comprises modulation means for converting input data signals into output signals suitable for transmission over the electrical transmission lines, followed by means for modulating the output signals onto an optical signal;

(c) the interface has optoelectrical conversion means arranged to recover said output signals and feed them to the electrical transmission line serving the relevant user termination.

The optical carriers may be carrier waves, different carrier waves having different frequencies, so as to form respective wavelength channels. In order to carry data, each optical carrier can then be modulated with the data to be carried over that carrier. In this situation, at least some of the carrier waves will preferably be transmitted over a common transmission medium, such as a common optical fibre, in a wavelength division multiplexed manner. Wavelength division multiplexing means such as a wavelength-dependent coupler means will preferably be provided at the exchange, to allow different wavelength channels to be combined over a common optical medium.

Alternatively, the optical carriers may each be formed by a respective optical transmission line, such as an optical fibre. The optical fibres may be grouped so as to form an optical fibre cable.

Some embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings.

Figure 2 shows part of a telecommunications system in accordance with a first version of the invention, which is similar to that shown in Figure 1 in that it utilises optical fibre from the exchange to the cabinet, whilst from the cabinet to the subscriber premises it shares the twisted-pair lines with conventional telephony. In this arrangement, however the aim is to reduce the amount of electronics installed in the cabinet. In this particular version, the optical fibre is used only for downstream transmission; upstream data transmission (if required) is provided using the copper pairs from the subscriber premises to the exchange, using the same techniques as in a conventional ADSL system, via modulators 30 in the subscriber's data equipment and demodulators 31 in the exchange 1. No multiplexing is employed on the optical fibres 10, so one fibre 10 is provided for each of the subscriber lines 6 that is to be provided with broadband service. No demultiplexers are employed in the cabinets 4. Moreover, appropriate modulation for converting digital data into a form suitable for downstream transmission on the twisted pairs 4, 6 is provide by xDSL modulators 32 in the exchange 1. These modulators are conventional and operated in the same manner as the modulator parts of the modems 15 of Figure 1, using any technique suited to the purpose, for example, discrete multitone (DMT) modulation, or carrierless amplitude/phase (CAP) modulation. The modulated output of each modulator then modulates a laser 33.

In the cabinet 4, it is merely necessary to convert the modulated optical signal received over the fibre 10 into electrical form, and apply this signal via a suitable high-pass filter 34 to the appropriate pair within one of the cables 4. In this, the simplest implementation of the invention, this conversion is performed by zero-bias PIN photodiodes 35, and then supplied to the cables 4 via high-pass filters 26. No power supply to the cabinet is required. Since the frequencies would be low (less than 1GHz) a large area diode could be used, allowing simple low cost alignment, and high power operation (typically 0 to +10 dBm).

At the subscriber premises, the downstream signals are received from the splitter/combiner 16 (shown as separate high-pass and low-pass filters 16a, 16b) by an xDSL demodulator 36.

Note that it is not necessary that the interface between the fibres 10 and the copper cabling should occur in the cabinet 4, as it could equally well occur at the distribution point 5 or indeed other intermediate location between the exchange and the subscriber's premises.

If however it is preferred to provide photodiode bias, this could be provided by means of a local power supply, by drawing power from the d.c. applied by the exchange to the line 2 (for example as shown at 39 in Figure 2 for one diode), or by supplying power from the subscriber premises over the pair 6.

If one prefers not to provide an upstream data path using copper all the way back to the exchange as envisaged in Figure 2, then one could use the fibres bidirectionally, as illustrated in Figure 3. Here the downstream arrangements are as described with reference to Figure 2, but the subscriber has an xDSL modem 40 which is entirely conventional. In the cabinet 3, the upstream signals from the line 4 are fed via a high-pass filter 41 to a laser diode 42 to generate an optical signal which is received by a photodiode 43 at the exchange 1 and supplied to an xDSL modem 44. The high-pass filters 36,41 are tuned to the respective parts of the frequency spectrum corresponding to downstream and upstream signals respectively. Note that in fact it is not essential that the equipment 33, 43, 44 be sited at the exchange 1, as they could if desired be at some other exchange, or any other location to which the fibres 10 can conveniently be connected.

In a yet further modification, in order to reduce the amount of fibre required the technique shown in figure 3 could be combined with a WDM PON as shown in figure 4. The subscriber has an XDSL modem 40 which is and is connected to an individual twisted copper pair 4. In the cabinet 3, the upstream electrical signals from the line 4 are fed via a high-pass filter 41 to modulate the optical signal produced by a laser diode 42. The laser diode 42 consists of a Fabry-Perot laser diode which in a free running state would generate light at a series of wavelengths whose wavelength spacing is regular and determined by the properties of the laser diode. The laser diode is arranged so as to predominatly generate light at one wavelength determined by the wavelength of an optical signal which is fed to it in this example from the exchange. For example, figure 4 shows light over a broad range of wavelengths being generated by a broadband light source (e.g. erbium doped fibre amplifier) 45 in the exchange and fed via an optical circulator 46 to an optical fibre 10. In the cabinet the optical fibre is connected to a wavelength dependant splitter/combiner 47 such as a thin film filter or arrayed waveguide grating which selects a particular wavelength λ_{LN} and passes it to the laser diode 42. The laser diode then generates light at wavelength λ_{LN} modulated with the upstream data and transmits it via the wavelength dependabt splitter/combiner and the optical fibre 10 to the exchange. In the exchange the optical signal passes via

the optical circulator 46 to a second wavelength dependant splitter/combiner 48. The wavelength dependant splitter/combiner 48 is connected to a plurality of photodiodes 43 which each receive light at a particular wavelength (each wavelength carrying upstream data from a particular customer which is thus supplied to an XDSL modem in the exchange).

In the downstream direction, a second broadband light source 49 generates light at over a different band of wavelengths to the first light source 45. For example, if the first and second broadband light sources 45 and 49 were erbium dopes fibre amplifiers then one could supply wavelengths in the so called "C-band" and the other in the so called "L-band"[of an ITU standard]. The broadband light source 49 is connected via an optical circulator 50 and a further wavelength dependant splitter/combiner 51 to a set of laser diodes 52, which again consist of Fabry Perot laser diodes. In this way each of the laser diodes 52 generates light at a different wavelength depending which port on the wavelength dependant splitter/combiner it is connected to. Each of the laser diodes 52 is modulated with the downstream output from one 321 322 of a set of XDSL modulators in the exchange 32. The modulated downstream optical signals from the laser diodes 52 pass from the exchange along the optical fibre to the cabinet 3. Simple 1x2 WDM optical wavelength band splitter/combiner filters 53 and 54 allow the optical signals produced by each of the two broadband light sources to share the same single optical fibre. The transmission of the wavelength dependant splitter/combiner 47 as a function of wavelength is periodic such that the upstream and downstream data for a particular customer propagate along the same optical fibre. On arriving at the cabinet 3, the modulated downstream optical signals are passed by the wavelength dependant splitter/combiner 47 to a device such as a zero-bias PIN photodiode 35 which converts the signal to an electrical form and applies it via a suitable high pass filter 26 to the appropriate twisted copper pair 6 for the customer. Optionally the laser diodes 42 and photodiodes 35 located in the cabinet could be fed with a low level of dc power from the subscriber premises over the copper pair 6. It is not necessary for the interface between the fibres 10 and copper cabling to occir in the cabinet 3 as this could equally occur at the distribution point 5 or indeed other intermediate location between the exchange and the subscriber's premises. Furthermore, the broadband light sources (e.g. 49) and laser diodes (e.g. 52) in the exchange could alternatively be replaced by a set of wavelength specified DFB lasers.

In a yet further modification, the photodiode 35 and laser 42 in Figure 3 could be replaced by an electroabsorption modulator serving both to detect the downstream

optical signal, and modulate the signal for the upstream path. It employs a two way fibre link from the cabinet to the exchange and utilises an electroabsorption modulator to both detect the optical signal on the down path, and modulate the signal for the return path. xDSL modulation would be applied to the laser within the exchange which would terminate optically on the modulator either in the cabinet or at the DP. The return xDSL signal from the subscriber end would be applied to the modulator which in turn would modulate the optical signal reflected back to the exchange. Given that the upstream and downstream signals are separated in frequency, demodulation becomes a matter of appropriate passive filtering. It is envisaged that the modulator would operate in reflection mode thus requiring only one fibre. Separate contacts could be used to define detector and modulator sections which could be combined with dual wavelength operation.

With embodiments of this invention, the data for each customer or each termination unit can be transmitted in DSL format, from the exchange - over an optical fibre for at least part of the journey and over a copper pair for the remainder of the journey. One advantage of this is that the equipment at the cabinet/kerb could be passive and require no electrical powering or at least much reduced optical powering.

Electroabsorbtion modulators are described in our international patent application WO98/04057.

CLAIMS

1. A telecommunications network comprising:

a telephone exchange;

electrical transmission lines connecting the exchange to user terminations;

data transmission means;

optical carriers connecting the data transmission means to at least one interface, located between the exchange and user terminations, for converting optical signals from an optical carrier into electrical signals for transmission over one of the electrical transmission lines;

wherein, for each of a plurality of user terminations requiring data service:

(a) a dedicated one of said optical carriers is provided;

(b) the data transmission means comprises modulation means for converting input data signals into output signals suitable for transmission over the electrical transmission lines, followed by means for modulating the output signals onto an optical signal;

(c) the interface has optoelectrical conversion means arranged to recover said output signals and feed them to the electrical transmission line serving the relevant user termination.

2. A network according to claim 1 including data reception means, connected at the exchange to the electrical transmission lines for receiving data from the user terminations.

3. A network according to claim 1 including data reception means, connected to the optical carriers for receiving data from the user terminations, wherein the interface includes electrooptical conversion means arranged to receive signals from the electrical transmission lines and feed them to the optical carrier serving the relevant user termination.

4. A network according to any preceding claim in which the optoelectrical conversion means and the electrooptical conversion means are together provided by an electroabsorption modulator.

5. A network according to claim 1, 2 or 3 in which the optoelectrical conversion means is a zero-bias photodiode.

6. A network according to claim 1, 2 or 3 in which the optoelectrical conversion means is a semiconductor device, and including means to draw power from the electrical transmission lines for providing power to the semiconductor device.

7. A network according to claim 6 in which the optoelectrical conversion means is a photodiode, and the means to draw power from the electrical transmission lines are arranged to provide photodiode bias.

8. A network according to claim 7 in which the electrooptical and/or the optoelectrical conversion means is a Fabry Perot laser diode having an output wavelength, wherein the output wavelength is determined by a seed wavelength fed to it from the exchange, the means to draw power from the electrical transmission lines being arranged to provide laser diode bias.

9. A network as claimed in any preceding claim, wherein the optical carriers are each formed by a respective wavelength channel.

10. A network as claimed in claim 9, wherein at least some of the wavelength channels are carried over a common optical medium, preferably over a common optical fibre.

11. A network as claimed in any of claims 1 to 8, wherein the optical carriers are each formed by a respective optical transmission line.

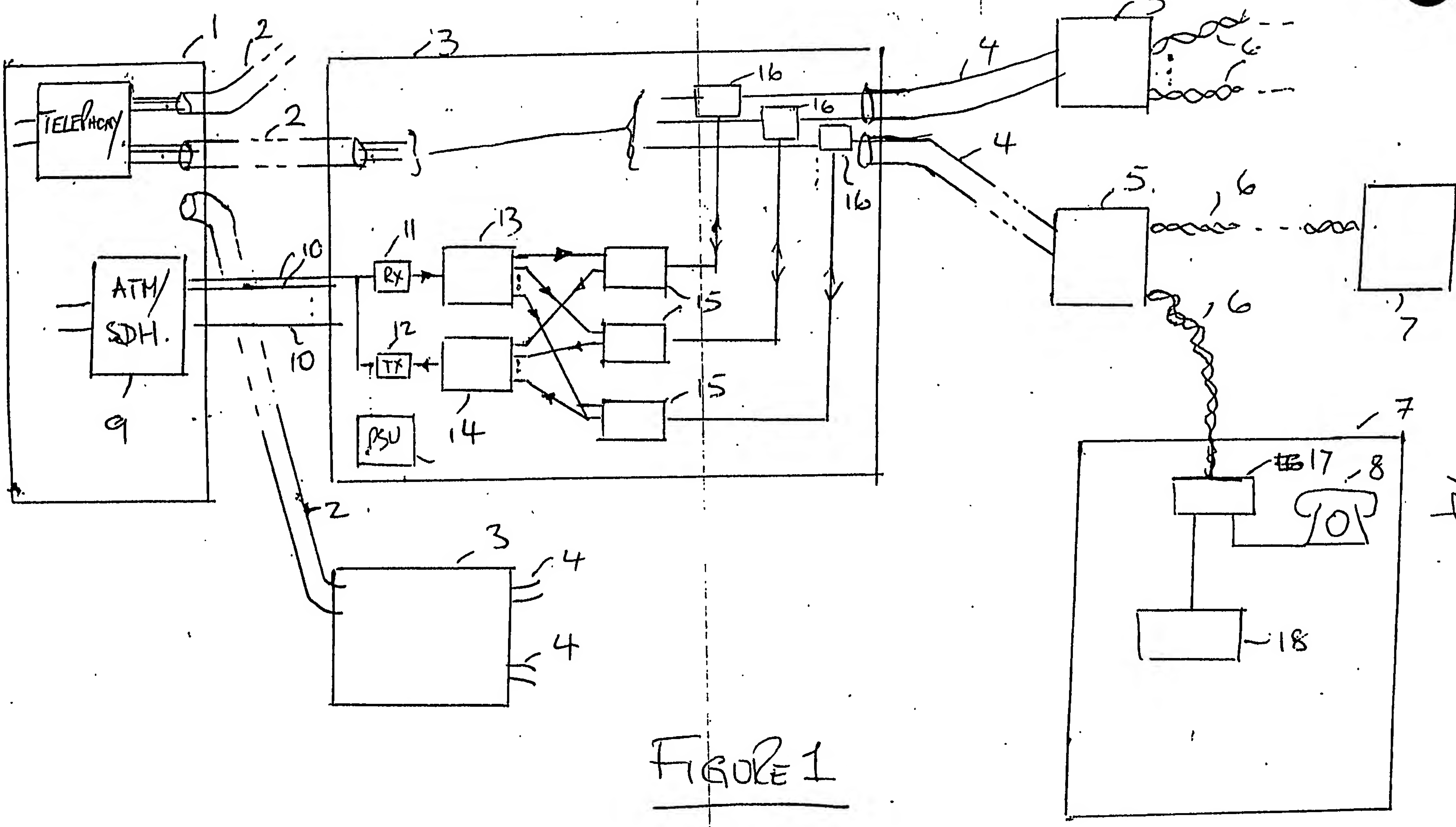

FIGURE 1

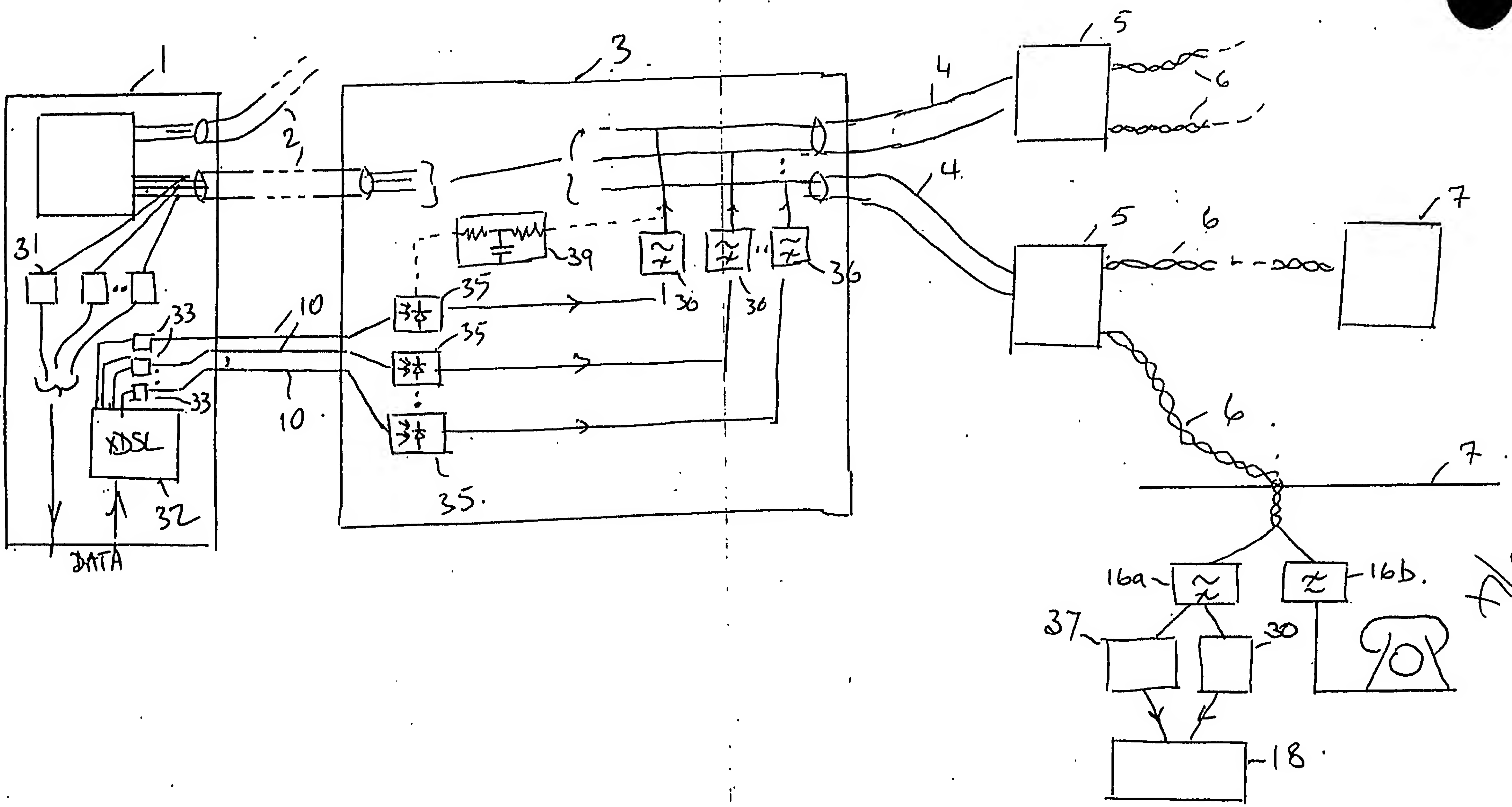

Figure 2

3/4

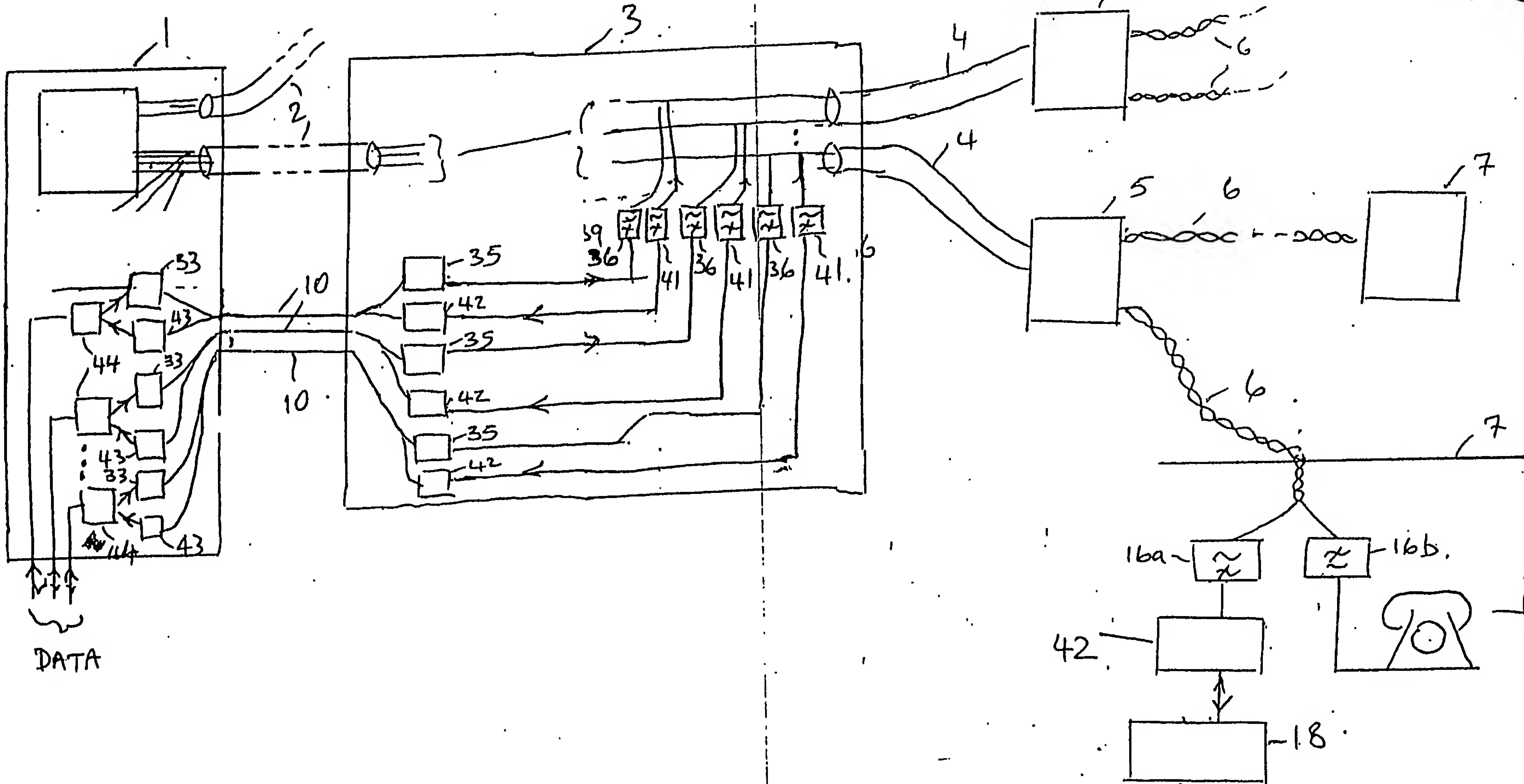

Figure 3

Passive fibre to the cabinet with WDM-PON

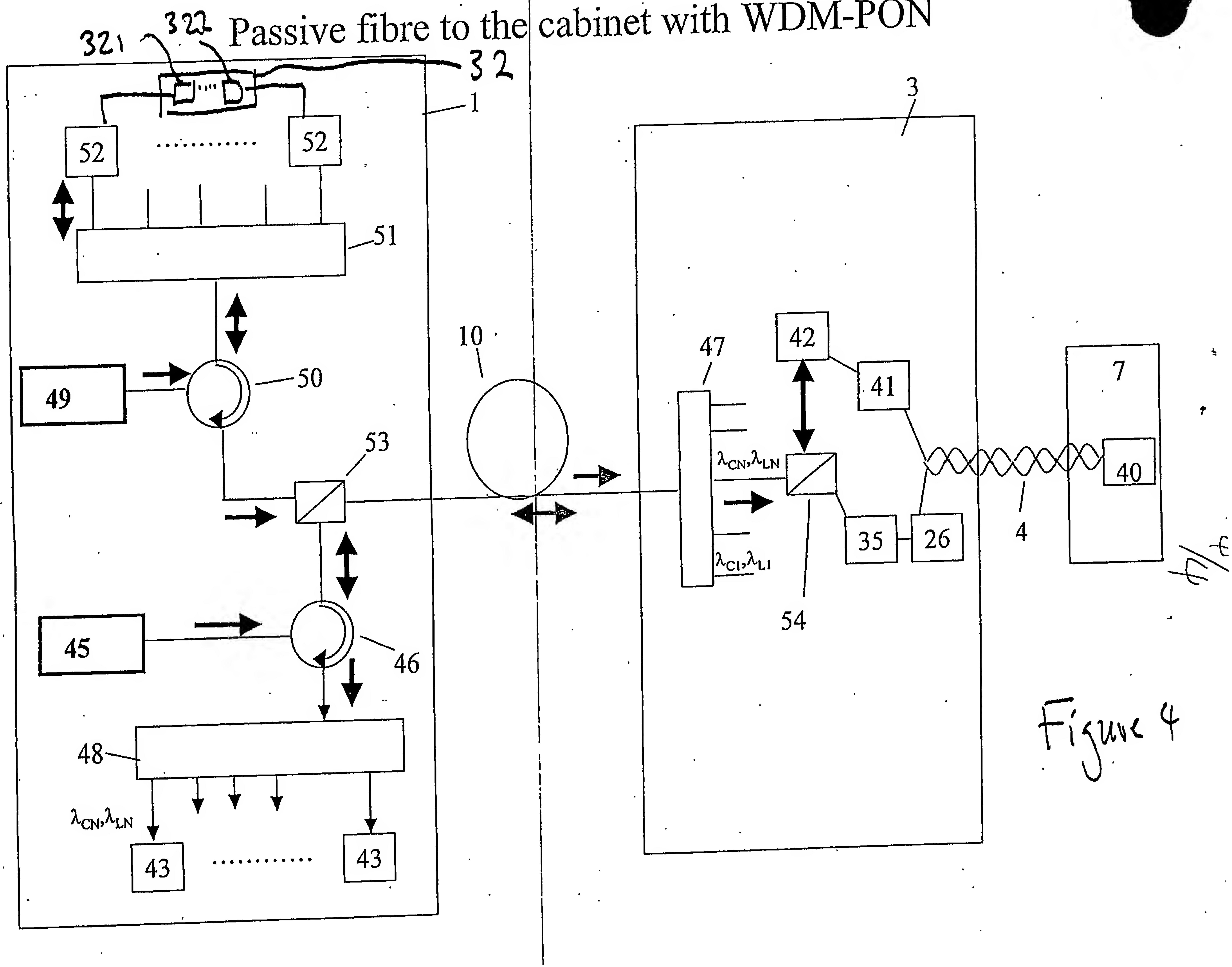

Figure 4

4/4